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Unusual nanosized associates of carboxy-calix[4]resorcinarene and cetylpyridinium chloride: the macrocycle as a glue for surfactant micelles

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Abstract

© The Royal Society of Chemistry. The association of cetylpyridinium chloride (CPC) micelles in the presence of octaacetated tetraphenyleneoxymethylcalix[4]resorcinarene (CR) leads to the formation of unusual spherical supramolecular nanoparticles (SNPs). Within the range of CR/CPC molar ratios from 10/1 to 1/10 (except for 1/8), CR, acting as a counterion, decreases the critical micelle concentration of CPC by one order of magnitude and leads to the formation of SNPs with an average hydrodynamic radius of 164 nm and an average zeta potential of −60 mV. The formation of SNPs was studied by NMR FT-PGSE and 2D NOESY, DLS, TEM, fluorimetry, and UV-Vis methods. The stability of SNPs at different temperatures and pH values and in the presence of electrolytes was investigated. The specificity of the interactions of the SNPs with substrates that were preferentially bound by a macrocycle or CPC micelle was studied. The enhancement of cation dye binding in the presence of SNPs is shown. The presented supramolecular system may serve as a nanocapsule for water-soluble and water-insoluble compounds.

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References

[1] A. A. Karim Q. Dou Z. Li X. J. Loh Chem.-Asian J. 2016 11 1300-1321
[2] Y. Zhou H. Li Y.-W. Yang Chin. Chem. Lett. 2015 26 825-828
[3] L. Ya. Zakharova R. R. Kashapov T. N. Pashirova A. B. Mirgorodskaya O. G. Sinyashin Mendeleev Commun. 2016 26 457-468
[4] G. Yu K. Jie F. Huang Chem. Rev. 2015 115 7240-7303
[5] Y.-X. Wang D.-Sh. Guo Y.-Ch. Duan Y.-J. Wang Y. Liu Sci. Rep. 2015 5 9019
[6] A. Feng J. Yuan Macromol. Rapid Commun. 2014 35 767-779
[7] P. J. Honey J. Rijo A. Anju K. P. Anoop Acta Pharm. Sin. B 2014 4 120-127
[8] Zh. Qi Ch. A. Schalley Acc. Chem. Res. 2014 47 2222-2233
[9] X. Ma Y. Zhao Chem. Rev. 2015 115 7794-7839
[10] Pr. Kaur T. Garg G. Rath R. S. R. Murthy A. K. Goyal Drug Delivery 2016 23 727-738
[11] S. Lankalapalli V. R. M. Kolapalli Indian J. Pharm. Sci. 2009 71 481-487
[12] S. dos Santos, B.Medronho, T.dos Santos and F. E.Antunes, in Drug Delivery Systems: Advanced Technologies Potentially Applicable in Personalised Treatment, ed. J. Coelho, Springer, 2013, pp. 35-85
[13] L. X. Jiang J. B. Huang A. Bahramian P. X. Li R. K. Thomas J. Penfold Langmuir 2012 28 327-338
[14] A. Barbetta, C.La Mesa, L.Muzi, C.Pucci, G.Risuleo and F.Tardani, in Nanobiotechnology, ed. W. Ahmed and D. A. Phoenix, One Central Press, 2014, vol. 7, pp. 152-179

[15] Sh. Peng K. Wang D.-Sh. Guoa Y. Liu Soft Matter 2015 11 290-296

[16] Ju. E. Morozova V. V. Syakaev A. M. Ermakova Ya. V. Shalaeva E. Kh. Kazakova A. I. Konovalov Colloids Surf., A 2015 481 400-406

[17] E. V. Ukhatskaya S. V. Kurkov S. E. Matthews Th. Loftsson J. Inclusion Phenom. Macrocyclic Chem. 2014 79 47-55

[18] S. A. Ahmed A. Chatterjee B. Maity D. Seth J. Photochem. Photobiol., B 2016 161 59-70

[19] J. H. Mondal T. Ghosh S. Ahmed D. Das Langmuir 2014 30 11528-11534

[20] M. Tsianou A. I. Fajalia Langmuir 2014 30 13754-13764

[21] A. J. M. Valente O. Söderman Adv. Colloid Interface Sci. 2014 205 56-176

[22] J. G. Harangozo V. Wintgens Z. Miskolczy J.-M. Guigner C. Amiel L. Biczók Langmuir 2016 32 10651-10658

[23] X. Ma Ya. Zhao Chem. Rev. 2015 115 7794-7839

[24] Sh. Peng J. Gao Y. Liu D.-Sh. Guo Chem. Commun. 2015 51 16557-16560

[25] W.-Ch. Geng Y.-C. Liu Y.-Y. Wang Zh. Xu Zh. Zheng Ch.-B. Yang D.-Sh. Guo Chem. Commun. 2017 53 392-395 Zh. Xu Sh. Peng Y.-Y. Wang J.-K. Zhang A. I. Lazar D.-Sh. Guo Adv. Mater. 2016 28 7666-7671

[26] R. V. Rodik V. I. Boyko V. I. Kalchenko Curr. Med. Chem. 2009 16 1630-1655

[27] Y. Cao Y. Wang D. Guo Y. Liu Sci. China: Chem. 2014 57 371-378

[28] G. Gattuso A. Notti A. Pappalardo S. Pappalardo M. F. Parisi F. Puntoriero Tetrahedron Lett. 2013 54 188-191

[29] N. Basilio M. Martín-Pastor L. García-Río Langmuir 2012 28 6561-6568

[30] T. N. Pashirova A. Yu. Ziganshina E. D. Sultanova S. S. Lukashenko Yu. R. Kudryashova E. P. Zhiltsova L. Ya. Zakharova A. I. Konovalov Colloids Surf., A 2014 448 67-72

[31] N. Basilio L. Garcia-Rio Chem.-Eur. J. 2009 15 9315-9319

[32] N. Basilio M. Martín-Pastor L. García-Río Langmuir 2012 28 6561-6568

[33] Zh. Li Ch. Hu Y. Cheng H. Xu Xu. Cao X. Song H. Zhang Y. Liu Sci. China: Chem. 2012 55 2063-2068

[34] K. Wang D.-S. Guo X. Wang Y. Liu ACS Nano 2011 5 2880-2894

[35] V. Francisco N. Basilio L. Garcia-Rio J. R. Leis E. F. Maques C. Vázquez-Vázquez Chem. Commun. 2010 46 6551-6553

[36] C. Bize J.-Ch. Garrigues M. Blanzat I. Rico-Lattes O. Bistri B. Colasson O. Reinaud Chem. Commun. 2010 46 586-588

[37] G. A. Gaynanova A. M. Bekmukhametova R. R. Kashapov A. Yu. Ziganshina L. Ya. Zakharova Chem. Phys. Lett. 2016 652 190-194

[38] R. R. Kashapov T. N. Pashirova S. V. Kharlamov A. Yu. Ziganshina E. P. Ziltsova S. S. Lukashenko L. Ya. Zakharova W. D. Habicher Sh. K. Latypov A. I. Konovalov Phys. Chem. Chem. Phys. 2011 13 15891-15898

[39] R. R. Kashapov R. I. Rassadkina A. Yu. Ziganshina R. K. Mukhitova V. A. Mamedov N. A. Zhukova M. K. Kadirov I. R. Nizameev L. Ya. Zakharova O. G. Sinyashin RSC Adv. 2016 6 38548-38552

[40] M. Karimi P. S. Zangabad A. Ghasemi M. Amiri M. Bahrami H. Malekzad H. Gh. Asl Z. Mahdieh M. Bozorgomid A. Ghasemi M. R. R. T. Boyuk M. R. Hamblin ACS Appl. Mater. Interfaces 2016 8 21107-21133

[41] M. E. Caldorera-Moore W. B. Liechty N. A. Peppas Acc. Chem. Res. 2011 44 1061-1070

[42] V. V. Syakaev E. Kh. Kazakova Ju. E. Morozova Ya. V. Shalaeva Sh. K. Latypov A. I. Konovalov J. Colloid Interface Sci. 2012 370 19-26

[43] E. Kazakova Ju. Morozova D. Mironova V. Syakaev L. Muslinkina A. Konovalov Supramol. Chem. 2013 25 831-841

[44] D. Mironova L. Muslinkina V. Syakaev Ju. Morozova V. Yanilkin A. Konovalov E. Kazakova J. Colloid Interface Sci. 2013 407 148-154

[45] Ju. E. Morozova V. V. Syakaev E. Kh. Kazakova Ya. V. Shalaeva I. R. Nizameev M. K. Kadirov A. D. Voloshina V. V. Zobov A. I. Konovalov Soft Matter 2016 12 5590-5599

[46] C. Bonaccorso S. Gentile F. G. Gulino D. Sciotto Lett. Org. Chem. 2009 6 598-603

[47] V. V. Syakaev A. R. Mustafina Ju. G. Elistratova Sh. K. Latypov A. I. Konovalov Supramol. Chem. 2008 20 453-460

[48] J. Akbari M. Saeedi K. Morteza-Semnani H. Kelidari M. Lashkari Adv. Pharm. Bull. 2014 4 385-390

[49] L. M. Schaeffer G. Szewczyk J. Nesta M. Vandeven L. Du-Thumm M. I. Williams E. Arvanitidou J. Clin. Dent. 2011 22 183-186

[50] M. I. Williams J. Clin. Dent. 2011 22 179-182

[51] M. M. Masadeh S. F. Gharaibeh K. H. Alzoubi S. I. Al-Azzam W. M. Obeidat J. Clin. Med. Res. 2013 5 389-394

[52] J. Karayil S. Kumar Y. Talmon P. A. Hassan B. V. R. Tata L. Sreejith J. Surfactants Deterg. 2016 19 849-860

[53] T. Mukhim J. Dey S. Das K. Ismail J. Colloid Interface Sci. 2010 350 511-515

[54] L. Abezgauz K. Kuperkar P. A. Hassan O. Ramon P. Bahadur D. Danino J. Colloid Interface Sci. 2010 342 83-92

[55] J. Bhattacharjee V. K. Aswal P. A. Hassan R. Pamu J. Narayananc J. Bellare Soft Matter 2012 8 10130-10140

[56] Sh. D. Choudhury N. Barooah V. K. Aswal H. Pal A. C. Bhasikuttana J. Mohanty Soft Matter 2014 10 3485-3493

[57] J. G. de la Torre M. L. Huertas B. Carrasco J. Magn. Reson. 2000 147 138-146

[58] G. B. Ray I. Chakraborty S. P. Moulik J. Colloid Interface Sci. 2006 294 248-254

[59] I. R. Knyazeva V. I. Sokolova M. Gruner W. D. Habicher V. V. Syakaev V. V. Khrizanforova B. M. Gabidullin A. T. Gubaidullin Yu. H. Budnikova A. R. Burilov M. A. Pudovik Tetrahedron Lett. 2013 54 3538-3542

[60] I. R. Knyazeva V. I. Matveeva V. V. Syakaev B. M. Gabidullin A. T. Gubaidullin M. Gruner W. D. Habicher A. R. Burilov M. A. Pudovik Tetrahedron Lett. 2014 55 7209-7214

[61] S. V. Kharlamov R. R. Kashapov T. N. Pashirova E. P. Zhiltsova S. S. Lukashenko A. Yu. Ziganshina A. T. Gubaidullin L. Ya. Zakharova M. Gruner W. D. Habicher A. I. Konovalov J. Phys. Chem. C 2013 117 20280-20288

[62] D. Varade T. Joshi V. K. Aswal P. S. Goyal P. A. Hassan P. Bahadur Colloids Surf., A 2005 259 95-101

[63] R. N. Dsouza U. Pischel W. M. Nau Chem. Rev. 2011 111 7941-7980

[64] Y.-J. Zhang W.-X. Cao J. Xu Chin. J. Chem. 2002 20 322-326